10030888 .060702
10/030888
531 Rec'd PCT 07 NOV 2001

[10191/2045]

DEVICE AND METHOD FOR CONTROLLING AN INTERNAL COMBUSTION ENGINE HAVING AN EXHAUST TREATMENT SYSTEM

Background Information

The present invention relates to a method and a device for controlling an internal combustion engine having an exhaust treatment system.

A method and a device for controlling an internal combustion engine having an exhaust treatment system is known from non-prior art German Patent No. 199 06 287. The system described in this document uses a particle filter that filters out particles contained in the exhaust gas. To precisely control an internal combustion engine having an exhaust treatment system, the status of the exhaust treatment system must be known. In particular, the filter's state of congestion, i.e., the volume of filtered-out particles, must be known.

Object of the Invention

In conjunction with a method and a device for controlling an internal combustion engine having an exhaust treatment system, the object of the present invention is to provide a method and a device that can be used to detect the status of the exhaust treatment system. In particular, the state of congestion must be detected even when different sensors fail or when no special sensors are used.

This object is achieved by the features described in the independent claims.

Advantages of the Invention

The method according to the present invention makes it possible to easily detect the status of the exhaust treatment system. Simulating the quantity that characterizes the status of the exhaust treatment system, based on at least one operating parameter of the internal combustion engine, eliminates the need for additional sensors. If additional sensors are used, they can be monitored and an emergency mode implemented. It is particularly advantageous that only those quantities are used for the simulation that are already being used to control the internal combustion engine.

It is particularly advantageous to use a quantity that characterizes the oxygen concentration in the exhaust gas. This can significantly improve the simulation of the status of the exhaust treatment system. This applies, in particular, to dynamic states, i.e., more accurate values can be achieved, particularly during acceleration.

Further especially advantageous embodiments are described in the subordinate claims.

Drawing

The present invention is explained below on the basis of the embodiments illustrated in the drawing. Figure 1 shows a block diagram of the device according to the present invention; Figure 2 shows a detailed representation of the simulation; Figure 3 shows a characteristic curve; and Figure 4 shows a further embodiment of the device according to the present invention.

Description of Exemplary Embodiments

The device according to the present invention is described below, based on the example of an internal combustion engine

having spontaneous ignition in which fuel metering is controlled by a common-rail system. However, the procedure according to the present invention is not limited to these systems. It can also be used with other internal combustion engines.

Reference number 100 designates an internal combustion engine which receives a supply of fresh air via an intake line 102 and discharges exhaust gases via an exhaust line 104. An exhaust treatment means 110, from which the cleaned exhaust gases pass through line 106 to the environment, is provided in exhaust line 104. Exhaust treatment means 110 essentially includes a primary catalytic converter 112 and a downstream filter 114. A temperature sensor 124, which provides a temperature signal T, is preferable located between primary catalytic converter 112 and filter 114. Sensors 120a and 120b are provided upstream from primary catalytic converter 112 and downstream from filter 114, respectively. These sensors act as differential-pressure sensors 120 and provide a differential-pressure signal DP, which characterizes the differential pressure between the inlet and outlet of the exhaust treatment means.

One particularly advantageous embodiment provides a sensor 125 that supplies a signal characterizing the oxygen concentration in the exhaust gas. As an alternative or additional feature, this quantity can be calculated on the basis of other measured values or be determined by a simulation.

Fuel is supplied to internal combustion engine 100 via a fuel metering unit 140. This unit meters fuel to the individual cylinders of internal combustion engine 100 via injectors 141, 142, 143 and 144. The fuel metering unit is preferably a common rail system. A high-pressure pump delivers fuel to an accumulator. The fuel passes from the accumulator to the internal combustion engine via the injectors.

Various sensors 151, which provide signals that characterize the status of the fuel metering unit, are attached to fuel metering unit 140. In the case of a common rail system, these include, for example, pressure P in the accumulator. Sensors 152 that characterize the status of the internal combustion engine are attached to internal combustion engine 100. These are preferably a speed sensor that provides a speed signal N and additional sensors that are not illustrated.

The output signals from these sensors are supplied to a control system 130, which is represented by a first control subsystem 132 and a second control subsystem 134. The two control subsystems preferably form a single structural unit. First control subsystem 132 preferably controls fuel metering unit 140 via control signals AD that influence fuel metering. For this purpose, first control subsystem 132 includes a fuel volume controller 136. The latter supplies a signal ME, which characterizes the volume to be injected, to second control subsystem 134.

Second control subsystem 134 preferably controls the exhaust treatment system, for which purpose it detects the corresponding sensor signals. Second control subsystem 134 also exchanges signals with first control subsystem 132, in particular those relating to injected fuel volume ME. Both control systems preferably make mutual use of the sensor signals and internal signals.

The first control subsystem, which is also referred to as engine controller 132, controls control signal AD for controlling fuel metering unit 140 as a function of various signals that characterize the operating state of fuel injection system 100, the status of fuel metering system 140 and the ambient conditions, as well as a signal that characterizes the desired power output and/or torque. Devices of this type are known and used in many different applications.

Particularly in the case of diesel-powered internal combustion engines, particle emissions can occur in the exhaust gas. In this case, exhaust treatment means 110 must filter these particles out of the exhaust gas. This filtering action causes particles to collect in filter 114. To clean the filter, these particles are then burned in certain operating states and/or at the end of certain time periods. For this purpose, the temperature in exhaust treatment means 110 is usually increased to the point at which the particles combust, thus regenerating filter 114.

Primary catalytic converter 112 is provided to increase the temperature. For example, the temperature is increased by increasing the proportion of uncombusted hydrocarbons in the exhaust gas. These uncombusted hydrocarbons then react in primary catalytic converter 112, thereby increasing its temperature and thus also the temperature of the exhaust gas that enters filter 114.

Increasing the temperature of the primary catalytic converter and exhaust gas in this manner increases fuel consumption and should therefore be carried out only when necessary, i.e., when a certain volume of particles has accumulated in filter 114. One way to detect the state of congestion is to measure differential pressure DP between the inlet and outlet of the exhaust treatment means and to determine the state of congestion based on this value. This requires a differential-pressure sensor 120.

According to the present invention, the anticipated particle emissions are determined on the basis of different quantities, in particular speed N and injected fuel volume ME, thereby simulating the state of congestion. Once a specific state of congestion has been reached, filter 114 is regenerated by controlling fuel metering unit 140. Instead of speed N and injected fuel volume ME, other signals that characterize these quantities can also be used. For example, the control signal,

in particular the control duration, for the injectors and/or a torque quantity can be used as fuel volume ME.

In one embodiment according to the present invention, not only injected fuel volume ME and speed N, but also temperature T in the exhaust treatment system is used to calculate the state of congestion. Sensor 124 is preferably used for this purpose. The quantity for the state of congestion calculated in this manner is then used to control the exhaust treatment system, i.e., regeneration is initiated by increasing the temperature, as a function of the state of congestion.

It is particularly advantageous to measure the state of congestion via differential-pressure sensor 120 in addition to calculating it. In this case, the system can be monitored for errors. This means using simulated quantity B and measured quantity BI of the state of congestion to detect errors in the exhaust treatment system. When an error in differential-pressure sensor 120 is detected, an emergency mode can be implemented to control the exhaust treatment system, using the simulated quantity that characterizes the state of congestion.

Figure 2 shows a block diagram that illustrates a method and a device for detecting the state of congestion, i.e., quantity B, which characterizes the status of the exhaust treatment system. Elements already described in Figure 1 are identified by the same reference numbers.

Output signals N of a speed sensor 152, a quantity ME of fuel metering controller 136, which characterizes the injected fuel volume, and/or a quantity characterizing the oxygen concentration, are supplied to a basic characteristic map 200. The quantity characterizing the oxygen concentration is preferably specified by a sensor or a calculation 125.

Basic characteristic map 200 applies a quantity GR, which characterizes the initial value of the particle emission, to a

first node 205. First node 205 applies a signal to a second node 210, which, in turn, applies a quantity KR, which characterizes particle increment in filter 114, to an integrator 220. Integrator 220 supplies a quantity B, which characterizes the status of the exhaust treatment system. This quantity B corresponds to the state of congestion of filter 114. Quantity B is provided to control system 130.

The output signal of a first adjustment element 230, to which is supplied the output signal of different sensors 235, is present at the second input of node 205. Sensors 235 supply signals that characterize, in particular, the ambient conditions. These include cooling water temperature TW, air temperature and air pressure PL. The output signal of a second adjustment element 240 is supplied to the second input of node 210 via a switching means 245. Output signal T of sensor 124 is supplied to second adjustment element 240. Alternatively, the output signal of a default-value generator 249 can also be supplied to the second input of second node 210 via switching means 245. Switching means 245 is controlled by an error detector 248.

It is particularly advantageous to influence the oxygen concentration in the exhaust gas with a further adjustment, corresponding to adjustment element 230.

Initial value GR of particle emission is stored in basic characteristic map 200 as a function of the operating state of the internal combustion engine, in particular speed N, injected volume ME and/or the quantity characterizing the oxygen concentration. It is particularly advantageous to use speed N and the quantity characterizing the oxygen concentration. In addition, it is advantageous to use speed N and injected volume ME.

Other quantities can also be used in addition to these quantities. Instead of volume ME, it is possible to use a quantity that characterizes the volume of injected fuel.

This value is adjusted in first node 205 as a function of the temperature of the cooling water and ambient air as well as atmospheric pressure. This adjustment takes into account their influence on the particle emission of internal combustion engine 100.

The influence of the catalytic converter temperature is taken into account in second node 210. The adjustment takes into account the fact that, above a certain temperature T1, the particles are not deposited in the filter but are directly converted to harmless components. Below this temperature T1, the particles are not converted, but are all deposited in the filter.

As a function of temperature T of exhaust treatment means 110, second adjustment element 240 sets a factor F by which basic emission GR is preferably multiplied.

Figure 3 shows the correlation between factor F and temperature T. Up to temperature T1, factor F assumes a value of 1. This means that, below temperature T1, initial value GR is linked to factor F in node 210 so that value KR is equal to value GR. Above temperature T1, factor F decreases and reaches a value of zero at a certain temperature T2, i.e., the entire particle emission is converted directly to harmless components, which means that no more particles are supplied to filter 114. If the temperature exceeds value T3, the factor assumes a negative value of x. This means that the congestion in filter 114 decreases even though particles are being supplied to filter 114.

If error detector 248 detects a defective temperature sensor T24, a default value from default-value generator 249 is used

instead of temperature value T. This default value is preferably also set as a function of different operating parameters, such as injected fuel volume ME.

Value KR, which has been adjusted in this manner and characterizes the particle value resulting in congestion of filter 114, is supplied to integrator 220. This integrator 220 sums up the quantity over time and emits a signal B that characterizes the state of congestion of filter 114. The adjusted output signal of the basic characteristic map is integrated to determine state of congestion B of filter 114.

Signal B, which characterizes the state of congestion of filter 114, is normally used directly to control the exhaust treatment system. The use of a simulated quantity eliminates the need for various sensors, particularly for differential-pressure sensor 120.

According to the present invention, the state of congestion is output from a characteristic map, based on at least the speed and/or the injected fuel volume or corresponding signals. The initial value determined in this manner is then adjusted. In particular, it is adjusted as a function of the temperature of the exhaust treatment means, in particular that of the particle filter. This adjustment takes into account continuous, temperature-dependent filter regeneration. Figure 4 shows a further especially advantageous embodiment. Reference number 400 designates the simulation element illustrated in Figure 2 to calculate state of congestion B. This simulation element 400 supplies a signal B for the state of congestion of filter 114. A further calculation element 420 is provided, to which output signal DP of differential-pressure sensor 120 is supplied. Both simulation element 400 and calculation element 420 supply signals to a switching means 410, which selects one or another of the signals and provides it to control system 130. Switching means 410 is controlled by an error detector 415.

Based on differential pressure DP, which is measured by differential-pressure sensor 120, air flow rate V can be calculated according to the following formula:

$$V = \frac{MH * R * T}{P + DP}$$

where quantity MH corresponds to the air rate measured by a sensor, while quantity R is a constant. Based on the air flow rate calculated in this manner, a characteristic map can preferably be used to calculate state of congestion BI.

The exhaust treatment system is controlled during normal operation based on this state of congestion BI. If an error occurs in the exhaust treatment system, in particular when detecting or recording differential pressure DP, error detector 415 controls switching means 410 so that signal B of simulation element 400 is used to control the exhaust treatment system.

In emergency mode, quantity (B) is used to control the exhaust treatment system. The system is controlled as a function of quantity (B), which characterizes the state of congestion, and/or additional signals. The simulated quantity can be used to implement a very accurate emergency mode. When used only in emergency mode, it is especially advantageous to use a simple simulation with only a few signals.

It is particularly advantageous to check the plausibility of calculated quantity (BI) and simulated quantity (B) of the state of congestion and to detect an error in the exhaust treatment system in the event of implausibility. Implausibility is detected, for example, when the difference between the two quantities is greater than a threshold value. This means that quantity (B) of the state of congestion is

used to detect the error. This procedure is a simple and accurate error detection method.